ress in aeronautics, all point to the fact that the scientific study of the atmosphere needs to be rapidly advanced in order to keep up with the branches of practical work and the business enterprises that these have instigated.—[C. A.]

THE WEATHER VERSUS COAL-MINE DISASTERS.

The great loss of life attending the operation of our mines many years ago led to the appointment of commissions to see what could be done to diminish or prevent such accidents, which were said to be due to the sudden exhalation of gases within the mines and their explosion by contact with the miners' lamps. It was even thought that forecasts of low atmospheric pressure might be made useful to the miners.

The present state of our knowledge of this subject is shown by the following extracts from letters communicated by the Acting Director of Mines, at Washington, D. C.:

The matter of the possibility of giving warning to mine managers at times of low barometer has been carefully considered by the staff of the Bureau. The investigations both in this country and abroad do not justify the belief that any particular relation can be established between explosions of fire damp and the low barometric conditions. It is believed that those are in error who think that the contrary has long been recognized. The Royal Commission on Explosions in Mines deprecated the issuance of colliery warnings by the Meteorological Service of Great Britain. Compilations of statistics of explosions have shown no increased dangers from low barometric conditions; in fact, in some cases the opposite has been indicated, but this seems probably a matter of chance.

It is true that if gas is allowed to accumulate in the open workings of mines it will tend to come out when there is low atmospheric pressure, but the accumulation of fire damp in old workings is not usual in the mines of this country. On the other hand, in active workings where gas is encountered, in almost all cases it issues at a vastly greater pressure than atmospheric; sometimes it will be several times atmospheric pressure, and, therefore, any slight differences in the atmospheric pressure could not possibly affect its issuance.

As far as the Dr. Haber fire-damp signal is concerned, that is not for forecasting, but it is to make known when there is a dangerous accumulation of fire damp. It depends upon the difference of density of fire damp as compared with air, which is manifested through a difference in tone of two whistles. In correspondence it does not appear that the device has reached a stage where it can be considered practicable; nor does Dr. Haber claim that it will show less than 1 or 2 per cent, which is shown by the ordinary safety lamp.

A later note from the Acting Director states:

It may be further mentioned that, while the engineers of the Bureau do not believe that it is wise to attach too much importance to the effect of low barometer, yet they are by no means neglecting to obtain the records in every case, after a mine explosion, from the Weather Bureau, supplemented by local records where such are to be had and, further, they are continuing to study this situation in gaseous mines whenever opportunity presents. Therefore the opinions expressed in the letter above mentioned must be considered tentative.

THE ULTIMATE CAUSE OF OUR WEATHER.

During the past two centuries meteorology has become a mass of observational data. From this we have compiled numerous statistical averages of the data in reference to time, locations, the position of the sun, and numerous other interesting and instructive relations. Everything seems tending toward the realization of man's hopes, viz, the determination of the reasons for the existence of this variable weather and its eventual forecasting. Our hypotheses and theories are plausible and rational, but we are still almost as far from the goal as our colleagues the magneticians.

In a recent lecture by Dr. L. A. Bauer, he concludes by some remarks:

THE CAUSE OF THE EARTH'S MAGNETISM.

Possibly by this time, if not before, you may have said to yourselves: "Granted that the compass needle points north and south because the earth itself is a magnet, what, in turn, causes the earth's magnetism, why are the magnetic poles not only not situated at the geographical poles, but not even diametrically opposite one another; or why, instead of wandering to and fro with the lapse of time, do not the magnetic poles remain fixed in position?" Lest any of these questions should cause you sleepless nights, let me say that, for the present at least, it would appear the better policy to confess ignorance. We may also take comfort in the fact that if the student of the earth's magnetism has not yet discovered the true cause of his science, neither has the investigator of magnetism, in general, been able as yet to answer the question: "What is a magnet?"

The most famous astronomer of his time, Simon Newcomb, one day entered the office of the associate editor of the Standard Dictionary, expressing his dissatisfaction with the tentative definitions for the words "magnet" and "magnetism," as based, in the absence of authoritative knowledge of the causes, simply upon the properties manifested. He was promptly requested to try his own hand. After writing and erasing alternately for an hour or more, he finally, with a hearty laugh, submitted the following pair of definitions: "Magnet, a body capable of exerting magnetic force." "Magnetic force, the force exerted by a magnet." Equivalent definitions will be found in Ambrose Bierce's "Devil's Dictionary" and, in explanation, the author cynically remarks that they were "condensed from the works of 1,000 scientists who have illuminated the subject with a great white light, to the inexpressible advancement of human knowledge."

But after all, it would seem that it is not so much the Why and Wherefore as the Therefore by which human progress is most advanced. Man, as the astronomer Littrow jokingly remarked, is "das Ursachen-Thier" who is ever incited and stimulated by his inquisitiveness as to the *cause* of things. Though he may never determine the "Endursachen" or ultimate causes, his inquiries lead him to acquire a vast amount of data with the aid of which he at least finds out the laws governing the phenomena under investigation.

The accumulation of data must at present be the chief aim of the student of the earth's magnetism. Perhaps no other subject can furnish more instances that, while theories as to the Why and Wherefore, though propounded by the most enlightened of the age, are short lived, the facts accumulated by observation and experience remain as permanent acquisitions to the storehouse of human knowledge.

THE PLANETS AND THE WEATHER.

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Dated, U. S. Weather Bureau, Washington, July 9, 1914.]

The weather and all its endless and manifold changes ultimately depend upon the reception and emission of radiant energy by the atmosphere and the surface of the earth. It is the eternal ebb and flow and ceaseless readjustment to equality of these two streams of energy that determine the temperatures of the atmosphere and establish its every temperature gradient. It is these, in turn, temperature and temperature differences, that give us evaporation, condensation, pressure gradients, wind velocities, and all or nearly all other elements of weather and weather changes.

Hence, nothing can influence the weather that has no effect on either of these energy streams. Conversely, everything that does modify these streams, either generally or locally, has a corresponding control over all weather elements and the climates of all places.

Do the planets, then, in any way affect the amount or distribution of radiant energy received by or lost from the earth? If they do, in that proportion, and in no greater, they obviously determine the weather and control its changes.

Now, there are just two known ways by which the planets can change the amount, but not the distribution,

of radiation reaching the earth, and, therefore, its temperature and other weather factors: (1) By changing their own brightness, through change of distance and phase; (2) by changing the earth's distance from the sun through the perturbations they produce in its orbit.

Change in planetary brightness.—The approximate effect of the first of these factors—change in the planetary brightness—is easily calculable. The light of all the planets, each at its maximum, is approximately that of 260 stars of the first magnitude, as the accompanying table shows, Venus alone contributing the light of about 209 such stars. On the other hand, the light of the sun is equal, roughly, to that of 73,000,000,000 first magnitude stars.

TABLE 1.—*Relative brightness of the planets.*

Name.	Stellar magnitude.	Date.	Equivalent, in first magnitude stars.
Mercury	−1.9	May 1, 1915	14.5
Venus	−4.8	Dec. 27, 1914–Jan. 6, 1915.	209.0
Mars	−1.3	Jan. 3–5, 1914	8.3
Jupiter	−2.5	Sept. 4–25, 1915	25.0
Saturn	−0.3	Dec. 16–25, 1914	3.3
Uranus	6.0	Opposition	0.01
Neptune	7.7	do	0.002

Venus and Mercury, being inner planets, change in brilliancy from maxima of the equivalent of about 210 and 15 first-magnitude stars, respectively, to minima that are at times actually zero. Mars changes the equivalent of about 8 stars of the first magnitude, Jupiter about 14, Saturn 1.5, Uranus and Neptune practically 0. Hence the total possible change is in the neighborhood of the equivalent of 240 first-magnitude stars, though the actual change is rarely greater than the equivalent of 230 such stars; that is, as simple division will show, a change in the total incoming and, assuming equilibrium, also in the outgoing radiation of 1 part in 300,000,000 is the utmost limit. The percentage change, however, in the outgoing energy, since the earth radiates very nearly as a black body and therefore in proportion to the 4th power of its absolute temperature, is approximately four times the percentage change of this absolute temperature. Hence the planets, through their variations in brightness, can alter the absolute temperature of the earth by only 1 part in 1,200,000,000. But the absolute temperature of the earth as a full radiator, its planetary temperature, is about 485°F., and therefore the above change can seldom exceed 0.000 000 4°F., or, say, one two-millionth of a degree F. at the surface of the earth—surely a negligible amount.

Change in earth's distance from the sun.—The second factor, however, the change of the earth's distance from the sun due to perturbations in its orbit caused by the planets, is, as we shall see, of much greater consequence, though it, too, is practically negligible in amount.

Jupiter changes the distance of the earth from the sun by about 1 part in 20,000; Venus and Mars each by about 1 part in 90,000; and the other planets by amounts so much smaller that their action may, in this case, be neglected. Since the perturbative effects of an inner planet on the course of the earth are more or less opposite to those due to an outer planet, especially at or near the times of their maxima, it will be sufficiently accurate to assume that the total change in the earth's distance from the sun, due to the combined action of all the planets, seldom is greater than 1 part in 17,000 of its average distance.

But the amount of radiation received by the earth from the sun varies inversely as the square of the distance between them. Hence the above change in this distance causes a change of 1 part in 8,500 of the earth's incident energy, and therefore, as already explained, one-fourth this latter fraction, or 1 part in 34,000, in its black-body absolute temperature of 485°F. Hence perturbations in the earth's path, due to the gravitational actions of the planets, may occasionally alter its temperature as a full radiator by 0.014°F., or the actual surface temperature, under the most favorable circumstances, possibly by as much as 0.02°F. Ordinarily, though perhaps not always, this too, so far as weather and climate are concerned, is a negligible temperature range.

So far as known, these are the only effects planets have on terrestrial weather and terrestrial climate. They are real and definitely calculable even though the one is always negligible and the other at least generally so. They therefore have nothing in common with the astrological or other nonsense that seems usually to be in the minds of those who insist that the planets do greatly influence or even control our weather and our climates.

The moon.—A word or two about the moon may also be interesting in this connection. The light of the full moon is the equivalent of about 128,000 stars of the first magnitude, and therefore by its radiation alone may, as a little calculation will show, change the earth's planetary temperature by 0.0002°F., or the surface temperature by, say, 0.00025°F.

But the moon and the earth rotate about their common center of gravity, a point some 3,000 miles from the center of the earth, and in this way the moon every month changes the earth's distance from the sun by approximately 6,000 miles. This in turn, as one may easily compute, changes the earth's planetary temperature by about 0.015°F., or its surface temperature by about 0.02°F. That is, it changes the surface temperatures through ranges whose maxima are approximately 0.01°F. on either side of the normal.

Both these lunar effects on the earth's temperature run their course once each lunar month, while the stellar effects are of much longer period. The chief stellar effect, being caused by the perturbations due to Jupiter, has a period of about 13 months.

The above, of course, does not exhaust all possible relations between the moon and weather, especially the weather of certain localities. It is known that not only the tides but also many ocean currents are more or less affected by the movements of the moon, and it is held by some earnest workers on this subject that these changes in turn either cause or are accompanied by small but measurable changes in the local weather of certain places. But this tidal effect is another story. It is only hinted at here with the object of guarding against the assumption that, as a scientific subject, it deserves to be dismissed with a "tut, tut" or a "pooh-pooh."